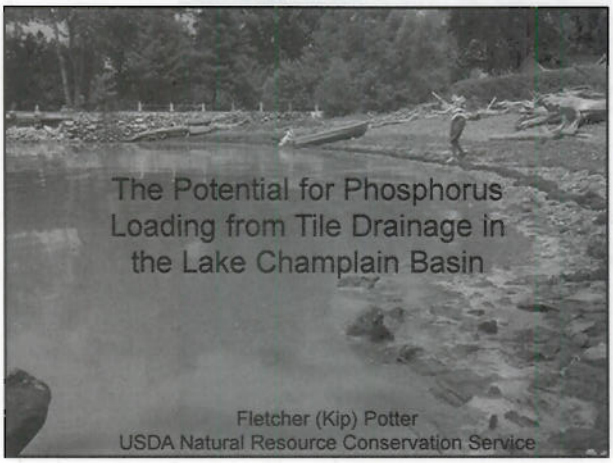
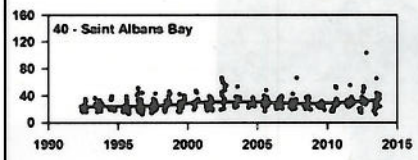


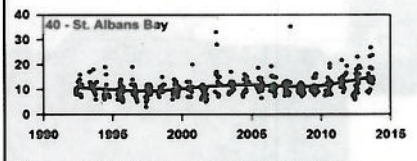
Introduction

- Soluble Phosphorus is readily available for plant/algae growth, compared to only 40 to 80 percent of Total Phosphorus (some of which is soluble phosphorus)
- Past conservation efforts have focused on controlling Phosphorus (P) loading by reducing erosion in surface runoff
- Most P reporting has focused on Total Phosphorus (TP)
- Trends in soluble P have been largely ignored
- Contributions of soluble P from tile drainage has also been largely ignored
- Overall, installing tile drainage may reduce P loading in some situations and increase it in other situations

Trends in TP and Soluble P (TDP) in St. Albans Bay



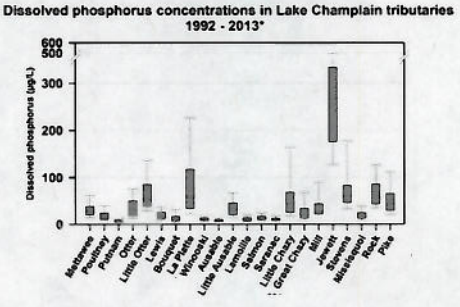
Total Phosphorus (TP) Concentrations (a 7% increase over last 5 years)



Soluble Phosphorus (TDP) Concentrations (a 20% increase over the last 5 years)

Source: VTDEC LC Long-term Monitoring Program

Soluble Phosphorus Concentrations (TDP) in Lake Champlain Tributaries



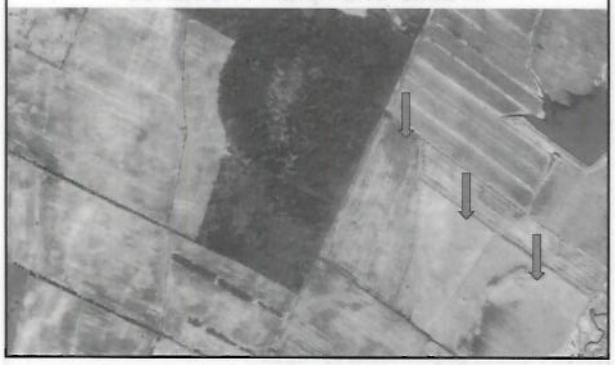
Source: VTDEC LC Long-term Monitoring Program

Potential Role of Tile Drainage in Phosphorus Loading - Introduction

- Heavy soils are common within the Champlain Valley, especially Addison, Rutland and Franklin Counties (over 86,000 ac. in Franklin County)
- Surface drainage of ag fields is common throughout the Basin, both in floodplains and upland areas
- In some watersheds more than 50% of ag fields may be tile drained
- Tile drainage is being installed at an accelerated rate in the LCB, including on fields under reduced tillage practices, on heavy clays and even on more moderately well drained soils
- New tile drainage systems are often laid out in more intensive grid systems
- There is a lack of data on tile drainage water flow amounts and on soluble P concentrations in tile water in the LCB

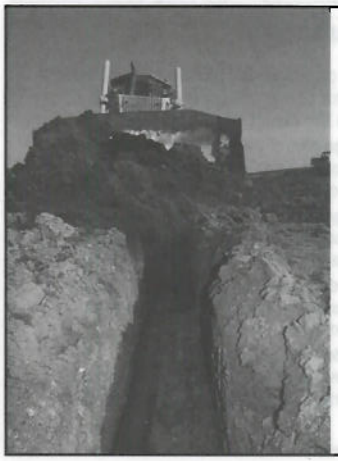
Example of Tile Drainage in Fields in the St. Albans Bay Watershed (Bing 2013 Imagery)

Example of Tile Drainage in Fields in the St. Albans Bay Watershed
(Bing 2013 Imagery)



Phosphorus Concentrations in Tile Drainage

- Literature Total Phosphorus (TP) concentrations range from around 100 ug/l up to 2,750 ug/l
- Limited samples from Vermont range from 180 to 610 ug/l Total Phosphorus (TP)
- In lake goal for Missisquoi Bay is 25 ug/l TP
- New in-stream standard for medium gradient streams in ag areas will be 27 ug/l TP (at baseflow conditions)
- Don't really know what the range and averages are for Vermont watersheds and how concentrations relate to other factors such as soil test P levels and how much is in the soluble form



So what do we know about tile drainage in the Lake Champlain Basin in regards to P loading?

Not Much – it is buried out of sight, both literally and figuratively

Field Level Studies

Quebec Study (Eastman et. al. 2010)

- Total combined surface and subsurface flow was 1.8 to 4 times greater from tiled fields compared to similar fields that were not tiled
- Overall P loading was less on a tiled sandy loam field (more on clay)

Wisconsin Study (Madison et. al 2014)

- Monitored surface and tile water flow, conc. and loading from 2 chisel plowed cornfields, one no-till soybean field and one pasture that were all tile drained
- Sub-surface drainage (tile) accounted for 66 to 96 percent of the total water discharged from the fields
- Average annual tile TP ranged from 210 to 1,320 ug/l (170 – 890 ug/l DP)
- Overall, tile drainage accounted for 17 to 41 percent of the TP
- On an event basis tile accounted for 36 to 72 percent of the DRP

Tracking Hydrologic Pathways of Phosphorus, Ewing Watershed, Qc (Watershed Level Water Yields and TP Export)

	Fall 2008	Spring 2009	
	Sept. 21–Dec. 8	Mar. 25–Jun. 21	
Water yields			
Groundwater / mm (%)	28 (40)[i]	58 (49)[i]	
Subsurface drains / mm (%)	34 (48)[i]	47 (40)[i]	
Surface Runoff / mm (%)	8 (12)[i]	12 (10)[i]	
Total / mm	70	117	
Phosphorus yields			
TP groundwater / g ha^{-1} (%)	24 (9)[i]	13 (4)[i]	
TP subsurface drains / g ha^{-1} (%)	82 (30)[i]	82 (28)[i]	0.07 lbs/ac
TP surface runoff / g ha^{-1} (%)	139 (50)[i]	121 (41)[i]	0.12 and 0.10 lbs/ac
TP other sources / g ha^{-1} (%)	31 (11)	77 (26)	
TP total / g ha^{-1}	276	293	0.2 and 0.3 lbs/ac

[i] Seasonal percentage

Poirier, Michaud, Whalen, 2012

Summary

- Overall on a field level tile drainage can increase "quick flow" to surface waters by a factor of 1.8 to 4 (watershed level increase would depend on the extent of tile drainage)
- On a field level tile drainage can change the dominant water flow pathway from a surface/groundwater pathway to a quick subsurface flow pathway (over 90% from tile in some cases)
- On a field level tile drainage in some cases can contribute more soluble and total phosphorus to surface waters than surface runoff ("back of the envelope" calculations – 10X)
- On a watershed basis tile drainage can account for a larger portion of water flow than surface water (up to 4 times as much depending on the extent of tile drainage)
- On a watershed level tile drainage can contribute a substantial portion of the overall P load to surface waters, plus most of it is in a soluble form that is readily available for plant and algae growth

Future Considerations and Efforts

- Need information on the extent of tile drainage in each watershed (airborne GPR?)
- Need more accurate quantitative data on P loading from tile drainage in LCB watersheds (inc. concentration data)
- Need to include tile drainage loading estimates as part of the TMDL goals (maybe have it as a subset of the crop field loading)
- Need to include tile drainage as part of routine farm resource assessments
- New assessment tools such as NC's PLAT?
- Need to test and implement a suite of conservation practices to reduce P loading from tile drainage, including:
  - Nutrient management
  - Phosphorus removal systems
  - Constructed wetlands
  - Soil amendments, including WTR's?
  - Drainage water management

Phosphorus Removal Systems

- New Vermont NRCS interim practice for
- Can include both subsurface (tile) and surface P removal systems
- Can be relatively easily installed "in-line" with existing and new tile systems in most situations
- First project will start next summer to install and evaluate two systems for tile drainage

Example P Removal Systems

Oklahoma Surface Phosphorus Removal System

Diagram of Tile Phosphorus Removal System